DOCUMENT RESUME

ED 048 774 24 EM 008 848

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TITLE	Development of Metropolitan (CITY III) Model. Final Report.
INSTITUTION	Envirometrics, Inc., Washington, D.C.
SPONS AGENCY	Office of Education (DHEW), Washington, D.C. Bureau of Research.
BUREAU NO	BR-9-0515
PUB DATE	Jun 70
CONTRACT	OEC-0-9-180515-4530(010)
NOTE	38p.; See also EM 008 849, EM 008 850, EM 008 851, EM 008 852
EDRS PRICE	EDRS Price MF-$0.65 HC-$3.29
DESCRIPTORS	City Demography, City Government, *City Planning, City Problems, Community Characteristics, *Computer Assisted Instruction, Computer Programs, Decision Making, Educational Games, Management Games, Metropolitan Areas, *Models, *Simulation, *Urban Areas, Urban Environment
IDENTIFIERS	*CITY III

ABSTRACT

CITY III, a computer-assisted simulation model to be used in the study of complex interactions and consequences of public and private decision-making in an urban setting, is described in this report. The users of the model, with the help of a computer, become public and private decision-makers in a simulated city and, by interacting with one another in dynamic situations, change the city. From 30 to 200 students may participate in running one of five "real" cities with populations ranging from 10,000 to 1.5 million. The CITY III model has three interrelated sectors: government, with an executive and councilmen who plan city growth, prepare budgets, and set tax rates; economic, in which private property owners and businessmen develop and operate eleven land uses of various densities; and social, in which workers and residents in three socioeconomic classes vote, allocate their time, and boycott stores and jobs. The report traces the history of mathematical models in the social sciences and delineates ten technical characteristics common to simulations. Several earlier urban simulation models are compared with CITY III. The important features of CITY III are summarized and also presented in tabular form. The simulation is intended for use with college or adult groups. (Author/JY)

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FINAL REPORT

OE Bureau of Research No. 9-0515

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DEVELOPMENT OF METROPOLITAN (CITY III) MODEL

Peter House
Envirometrics, Inc.
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Washington, D.C.

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The research reported herein was performed pursuant to a Contract with the Office of Education, U.S. Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

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Summary

The object of this project was to develop a highly flexible, modular, operational simulation model -- called CITY III -- that can be used to study, learn about, and experiment with the complex interactions and consequences of public and private decision-making within population centers. This operational simulation model is a computer-assisted device in which a wide range of population centers can be simulated. The users of the model become the public and private decision-makers of the simulated system and by interacting with one another on dynamic situations, change the system.

The CITY III Model as developed has three interrelated sectors: government, with an executive and councilmen who plan city growth, prepare budgets and set tax rates; economic, in which private property owners and businessmen develop and operate eleven land uses of various densities; and social, in which workers and residents in three socio-economic classes vote, allocate their time and boycott stores and jobs; all of these activities are played in two-hour rounds simulating a fiscal year. From 30 to 200 decision-makers may participate in running "real" cities from 10,000 to 1.5 million population.

The project was a complete success, as far as the development of a specific tool is concerned. The resultant model is several times richer than any of us anticipated when the study was first conceived. Its detailed description is contained in this report.

On the other hand, the development of this tool parallels in a small way the advance in computer technology itself where computers are becoming larger, more intricate, with greater capabilities. In both cases, the product is undeniably useful -- but much too complex for the uninitiated. The continuous desire to enhance flexibility and expand applicability has resulted in the development of a tool beyond the expertise of the casual user.

It is not possible to describe CITY III as a game with great precision, since a game has to be played or observed. Nonetheless, we have attempted to give potential users some basic assistance in the use of the model. The mere size of the Players' Manual alone (over 200 pages) will signify the level of sophistication achieved and the additional 100 or so pages of the Director's Guide and Operator's Manual give further evidence of our effort to clarify the model. Nevertheless, it is beyond the scope of this project to fully realize this goal.

In short, there is a very important second stage required to make this project truly operational by large numbers of users. That is the training stage. At present the model is not recommended for all elementary and most secondary school teachers. It could be introduced to some senior level classes provided that the teacher is sufficiently sophisticated and is willing to spend the considerable time necessary for classroom preparation. It is useful in many college level courses and in most graduate and adult education areas. Again, in addition to his own preparation,* in most cases the professor will need the assistance of the computer analyst to implement the model. In all cases, a great deal of experimentation in its installation and presentation must be accomplished before the model can be widely distributed. So far, it has only been operated by Envirometrics or with Envirometrics staff assistance.

* The model is presently operational only on a Univac 1108 computer using an Exec. 8 system.

Introduction

Man was first a generalist. Primitive man, in trying to comprehend his world, explained what he saw either in concrete terms, if he thought he understood, or in mystical terms, if he did not. Either way, his view was broad. In the early histories of many people, we see explanations of the world's beginning, the relationship of gods or of god to man, man to nature, and nature to nature, conceptualized as interrelated networks, chains of being, of which man himself is only a part.

As time passed man began to replace empirical evidence with speculation. Vast amounts of knowledge became available to those who could visualize man and his place in the universe. But this "knowledge explosion" exceeded what wise man could collect, collate, and correlate. The wise man did the prudent thing. He began to specialize. As the specialists probed deeper and deeper into the particular segments of natural, physical and social phenomena, they produced still more specialization. The original hand-carved throne of philosophy now sits in a lounge, if not an auditorium, full of modern chairs for many disciplines and sub-disciplines.

Marching with the formations of specialists are the theorists. Usually in front, the theorist performs two functions for the specialist: he is an advance scout helping to chart the terrain, and he helps to lay down the route so that newly joined specialists can follow the formation. In the first role, he discovers new horizons for the specialists to explore. In the second, he provides the language and boundaries within which the particular specialists can talk to each other without retracing their steps each time.

Unfortunately, while teh specialized jargon gives scientists an efficient shorthand, it keeps out scientists from other specialities, and the public as well. A philosopher cannot exchange meaningful information with a social psychologist because they do not even use the same language the same way. We might add that even the mother discipline of philosophy is now subdivided into specialities, which do not always talk the same language.

We do not here decry the specialization of knowledge. It was inevitably necessary for man to marshall his world. However, such specialization in the social sphere, which is our concern here, has not been without great cost.

Our point is that social scientists have become like members of the building trades. No one expects a master mason to paint walls after he plasters them. In fact, there are often strict sanctions placed on a plasterer if he does pick up a paint brush. Thus, the plasterer does not worry about the color or type of paint to be used on the walls. He tends to see the building in terms of his trade. In all, it is not unlike the social scientists. We think that many of our economists, sociologists, political scientists and public administrators as well as other social scientists follow the ways of the trade unions.

The building trades, however, have an architect to give them blueprints and a contractor to see that they are carried through. But, if the blighted building we're analogously trying to renovate is our urban environment, who will provide the blueprints or the framework within which the building trades of the social sector can work to solve urban problems?

As we know, our "urban" building needs attention badly. Its economic foundation is shaky. It is old and most of it is dilapidated, except for newer office rentals. People are crowded together in the lower floors while a few live in the sunlit top floors. Many are leaving the middle floors for split level residences some distance away where they can breathe clean pure air. Occasionally, fresh renovators come into one or two rooms on a lower floor to try out a new furniture arrangement. They move the residents out into more crowded basement rooms while they try out their ideas. Somehow, strangely, the dispossessed lodgers can never move back into their space. Others move in to occupy it. The dispossessed complain through disaffection, crime and rioting.

We are certain that the problems of our cities can be solved. We believe that the way to find the solutions is close at hand. We know that unless total solutions are found, the urban house will collapse or be burned down first.

Those who would do something share good intentions. Planners want to rebuild, but even if they had the right amount of money, they lack the blueprint with which to successfully circumscribe our cities. The social trade

unions want to rebuild, but they lack a framework within which to cross jurisdictional lines and work together. The public administrators, needing the contributions of the other two partners, cannot coordinate the remodeling of their cities.

Our analogy implied that an urban architect existed to replan our hypothetical house. Although he may evolve someday, such an intellectual giant with a comprehensive view does not exist that we know of. One person working mostly in the business sphere does offer us the approach with which to construct the immediate tools, however. He is the systems analyst.

His approach coupled with modern computer technology shows the way. For, if we cannot complete the circle by naming the generalist who ties man's selfmade environment together, just as primitive man generalized his natural environment, we can call out the approach which will provide the framework within which the specialists of the social sphere can meet and work profitably to solve urban problems. As a tool, computer-assisted operational simulation, a complex system about which very little is understood, shows great promise for the future.

Operational simulation offers the social scientist a laboratory, like that of the natural or physical scientist, in which he can test the results of his ideas on an urban environment. It is infinitely more sensible than the experimentation that goes on now with real cities. It is prohibitively expensive to try out new schemes on an existing city. It is illogical to begin such programs that cannot be completed. It is wasteful to disrupt cities for unproven programs. And, it is inhuman to use segments of the urban population as guinea pigs in experimental pens.

We champion simulation for positive, compelling reasons. First of all, simulation can provide an intense education about how an urban environment "works" because it uses a total systematic approach. In designing a simulation, the builders acquire a deep understanding of urbanology. They have to think through the dynamics and interrelationships among the system components, so that the simulation works like the real urban area. In playing a simulation, planners and administrators learn by being part of an abstracted area in which they can experience the interrelationships and dynamics among the system components.

Second, the simulation gives those concerned about the urban area a common language, so that they can exchange experiences, knowledge and information. Simulation hurdles the jargon problem so that game builders and the social science labor force can talk to each other and work with each other.

Third and finally, besides education, fully realized simulations can be used to help formulate policy. As a laboratory, a simulation would let a policy maker pretest his ideas and consider all possible alternatives and their consequences before one shovel is turned or any citizen is dispossessed.

Mathematical Models

In the recent past, other social scientists have also come to realize that traditional methodologies used in social science were not adequate to offer solutions for, or to train personnel to deal with current urban problems. The economists have led the rush away from a largely descriptive study of social science by adding the exactitude of mathematics to their theoretical base. Soon many branches of social science had turned to math models for explanations of, and solutions to, problems in their specialities.

The whole history of social science simulation has been, is, and will be inexorably tied to the continuing improvement of computer hardware and software. As noted above, urban man as a group animal is extremely complex. His habitat, the teeming city, is an intricate and involved phenomena. The city is difficult for science, especially the social sciences, to analyze. Many probing minds have been fascinated by the relationship of man within and to his city. But they have been forced to leave their talk in either descriptive terms or in vague generalities. Their attempts to describe these relationships precisely were very difficult. And even when attempted, the sheer manipulation required of the mass of data made validation impossible. The advent of the computer appeared to lessen the difficulty. Theeconometrician, the operations research analyst, and other social scientists soon began to be able to specify the functional relationships existing in society and to test these relationships empirically. With the high speed computer, they not only were able to handle large amounts of data and large numbers of complex mathematically defined relationships, but they could begin to integrate these relationships over long periods of time. The situation suggested the hope that social scientists might achieve some predictability in social action. The theory was fine.

However, the social scientist began to think of his fellow human beings as a cipher in a series of simultaneous equations. Further, as researchers began to demand more performance from their simulations and required that they handle matters which were not readily quantifiable, the mathematician was forced to turn to probability techniques, such as Monte-Carlo. Models then became more complex and simultaneously began to lose favor. Among the many reasons was the inability to translate the findings of the models into language which could be understood and used by the administrators and policy makers in the urban area. Further, many social scientists did not believe the results obtained represented a replication of reality.

Consequently, many of those searching for new techniques in the social sciences turned to gaming. Games were designed to teach young people in primary and secondary schools and colleges about major inputs in subject matter. However a large number of these early social science games were primitive and naive. The designers often took the term "game" in a parlor game sense and felt that adding complexity to the models only served to reduce enjoyment. On the other hand, a few of these models were well designed and did accomplish their limited teaching objectives.

The resulting models that developed varied widely. Some of the more important differences between the various models can be explained in terms of their characteristics which are shown in Figure 1. For referencing purposes, some of their use and institutional characteristics are exhibited in Figure 2. A discussion of each of these characteristics follows at this point in the text. Thereafter, examples of the simulation projects will be discussed qualitatively, using those characteristics as a contextual framework.

Technical Characteristics of Simulation Projects

1. Manual vs. Computer Assisted Simulations

Manual or hand operated simulations usually consist of a development board, pieces representing various types of development, rules, and some decision-making device, often dice. In general, they are easy to understand, cost little to operate and are easily transportable. Unfortunately, few factors can be taken into account and exploration of alternatives is a laborious task requiring much hand calculation. Computer-assisted simulations, on the other hand, offer advantages of speed, ability to handle large quantities of data and great numbers of variables. They usually consist of computer programs and maps, playing board, computer output and computer input forms. While they sometimes cost more than manual simulations to play, digital computers offer more economical operation than their predecessors and costs per unit of output will continue to fall in the near future. Although the models are also easily transportable, they often require very specialized electronic data processing equipment (usually a particular computer brand and model number) to function properly.

FIGURE 1

TECHNICAL CHARACTERISTICS OF ONGOING URBAN SIMULATION PROJECTS

Name of Simulation (alphabetical order)	Manual (M) or Computer Assisted (C)	Hypothetical (H) or Real Environment (R)	General (G) or Limited (L) Applicability	Modular (M) or Non-Modular (N)	Linked (L) or Unlinked (U)	Role playing (R) or Systemic Actions(S)	Win-Lose Strategy (Yes or No)	Time Period per Iteration, Maximum Feasible No. of Iterations (Approx.)	Artificial Grid (A) Real Parcels (R)	Computer Conversions
CITY III	C	H	G	N	U	S	No	1 year 10-15 Iter.	A	UNIVAC 1108 GE63
CLUG	M or C	H	L	N	U	S	No	1 year 20-30 Iter.	A	IBM 1130
GSPIA GAME	C	R	L	N	U	R	No	1 year 10-15 Iter.	A	IBM 7094
M.E.T.R.O.	C	R	L	N	U	R	No	1 year 10-20 Iter.	R	IBM 1130
THE METROPOLITAN MODEL (under development)	C	R	G	M	L	S	No	1 year 15-20 Iter.	R	UNIVAC 1108
METROPOLIS	M	R	L	N	U	R	No	1 year 10-20 Iter.	A	N/A
New Town	M	H	L	N	U	R	Yes	N/A	A	N/A
Urbanization	M	R	L	N	U	R	No	1 year 10-20 Iter.	A	N/A

FIGURE 2

INSTITUTIONAL CHARACTERISTICS OF ONGOING URBAN SIMULATION PROJECTS

NAME OF SIMULATION (Alphabetical Order)	FOCUS	PURPOSE	DEVELOPER	SPONSOR
CITY III	Simulate general social, economic and physical conditions in an urban environment.	General education	Envirometrics, Inc. Washington, D. C.	Federal-Government (DOT, OE) and private agencies (Washington Center for Metropolitan Studies
CLUG	Simulate land development	Education, especially urban Planners	Allan Feldt	Cornell University Ford Foundation
GSPIA Game	Simulate general social economic and physical conditions in an urban environment.	Training of City planners and other urban specialists	Clark Rogers, Frank Hendricks	University of Pittsburgh
M. E. T. R. O.	Simulate the developer, education political and planning functions of an urban area (Lansing, Mich.)	General education	Richard Duke and others	Michigan State University and University of Michigan
METROPOLIS	Simulate the developer, education political and planning functions of an urban area (Lansing, Mich.)	General education	Richard Duke and others	Michigan State University
METROPOLITAN MODEL (under development)	Simulate general social, economic, and physical conditions in an urban environment	General education. Training of professionals and para-professionals. Research and urban problems and their solution	Envirometrics, Inc. Washington, D. C.	Federal Government (DOT, USDA)
New Towns	Simulate Land Development of an Urban Area	General education	Barry Lawson	Private enterprise
Urbanization	Simulate Land Development of an Urban Area	Training for city planners, area itself, etc.	Carl Steinitz and Peter Rogers	Harvard University

2. Hypothetical vs. Real Simulated Environment

The simulation may deal with a hypothetical situation in which data is simply created with little similarity to a particular environment. Often data represent simply the national average of each variable. On the other hand, real data may be dealt with if the simulation of an actual situation is desired. Obviously, dealing with the real environment provides better opportunities for verification of accuracy of conclusions and processes. However, it is much more difficult to program and to calibrate the model to give realistic results. Often real data can only be feasibly handled in computer simulations.

3. General vs. Limited Applicability

Another distinction that may be drawn is whether the simulation can be applied to few or many environmental situations. If its applicability is limited to one or a few cities, for example, it is possible that greater detail may be achieved. If it is of more general applicability, for example, to all cities of 300,000 to 3,000,000 population, greater flexibility will probably be an important characteristic of the model.

4. Modular vs. Non-Modular

The model may be modular or non-modular. If it is non-modular, it has been conceived of and programmed as a unified whole. Changing any part of the model, or adding new components will require extensive reprogramming. If the model is modular, the interfaces between each of the components will be defined at the outset and each component can be programmed, modified, or replaced as desired. The modular model is thus much more flexible and changeable than the non-modular variety.

5. Linked vs. Non-linked

The model may or may not be linked to other models in which different activity systems or different levels of similar activity systems are simulated. These can be called horizontal and vertical linkages, respectively. For example, if a model projecting the population of a simulated city feeds into and receives feeds from a model which allocates residents to different areas of that city, the model are said to be horizontally linked. If,however, a model simulating environmental conditions in a metropolitan area feeds into and receives feeds from a model simulating conditions in the region in which the metropolitan area is

located, the models are vertically linked. Horizontal linkages are necessary in computer assisted models due to limited core capabilities and the necessity of using subroutines. Hereafter the term "linked" will refer only to vertical linkages.

6. Role-Playing or Systemic Action

Operational simulation models may be further distinguished by the types of functions that the decision-makers are given. In some models, the players are given a prepared description of the type of role they must play. There is usually some kind of competition implicated -- those "best" fulfilling the role make the best "score." In other simulations, the types of actions that the players can take are systemic: they are restricted only by the limits composed by the model complexity level. The interactions that occur depend on the players themselves.

7. Win-Lose Strategies

Another technical characteristic is that of win-lose strategies. Some models have a competition built in where, by some preset rules, there is a team or individual that "wins" by gaining an advantage over another team(s) or individual(s). The termination may be determined by a number of cycles, an absolute or relative score, or the mutual consent of the users. In other simulations, players may set their own goals individually or collectively, but they do not determine a winner or loser.

8. Time Period per Iteration and Maximum Feasible Number of Iterations

In general, simulations are accomplished in a series of steps. The steps represent periods of time, usually one year. Occasionally, longer periods are used. Each step, or round is one iteration of the model. The iterative process can be feasibly extended to some point beyond which results become meaningless or inaccurate, due to the influence of exogenous variables not accounted for in the model. That point is the maximum feasible number of iterations.

9. Artificial Dimension of Real Physical Parcels

Where there is a physical dimension in the model, space is dealt with in either of two ways. First, an artificial pattern of land divisions, usually a grid in which blocks of 1 square mile are represented, may be used.

Second, an attempt to approximate the dimensions and shapes of real parcels may be made. Obviously, where an artificial grid is imposed on a real area, problems arise in aggregating the socio-economic data to be used in the model, especially since most data is not collected on a grid basis. The real parcel arrangement allows for much greater accuracy in dealing with related socio-economic variables.

10. Computer Compatibility

The final technical characteristic is that of computer compatibility. Most computer assisted models are programmed to run on one particular type of machine. They can be converted for use with other machines. However, this is often a time consuming and costly process.

Urban Models

Early urban models were almost all supported by hand calculators or with other mechanical devices. Suddenly, as happens often in the sciences, a number of the designers of urban models derived, almost simultaneously, the idea that portions of highly sophisticated urban mathematical simulations which lacked the necessary human interplay could be improved by the use of a gaming situation. Richard Duke, then of Michigan State, developed two simulation models, Metropolis and M.E.T.R.O., both of which describe the urban area in a series of equations but allow a number of strategic inputs from humans playing general roles -- politicians, real estate operators, school officials, and planners. The University of Southern California has a project studying air pollution which uses a similar technique and Frank Hendrix of the University of Pittsburgh has also developed a mathematical model of this sort.

At the same time Allen Feldt of Cornell was designing the Community Land Use Game, which focused on the economic aspect of the urban area. This model did not attempt to describe the exact series of relationships between players, but set up a structure which allowed them to evolve their own detailed system -- the game only provided the general structure. This type of gaming is referred to as systemic gaming.

As these designers began to develop more complex urban gaming models they soon realized that there were a number of major drawbacks. First, there was difficulty in obtaining data to balance the models. For example, Feldt was contracted to construct an economic game of the Washington Metropolitan Area, and the help of all the six metropolitan planning agencies in gathering data was obtained. The year selected for simulation was 1960, a Federal census year. Even with the combined help of the area data banks, the great volume of census data, and the planning agency staffs, it was estimated that it would take $5,000,000 worth of additional research to get real-world data for the Washington model. Needless to say, his staff was forced to resort to educated estimates of many of the variables.

Second, social science theory was often not adequately defined to handle the proposed model. For example, the social science field is in need of a neighborhood model which can be used to teach and do research on central city problems. Unfortunately, we are not even sure of what a

neighborhood comprises. Consequently, there will have to be a great deal of exploratory research before work can even be started on the design of the model itself.

Finally, the gaming models had to be computer-oriented. The use of computers allows the designers to simulate society in a more detailed fashion and to allocate large portions of the mechanics of the model to the machine. This made possible increased complexity, more flexibility, and greater reality than was contained in their first models.

Methods

Operational Simulation

When Envirometrics first entered the field, it followed the lead of earlier gamers and divided urban modeling into three general types: mathematical, role-playing, and systemic. Mathematical modeling was left to all models of simulations which did not include human players. Role-playing games defined operations and win strategies for various players in segments of the model concerned. Systemic gaming allowed player win strategies to be developed by situations within the model and from the particular play itself.

With the concept of operational simulations, Envirometrics essentially combined the above methods into complex, urban simulations using players to represent population groups. The models are computer-assisted devices in which a system is simulated and the users of the model, by becoming the decision-makers of the system and interacting with one another in dynamic situations, change the system.

First Models

The first work of the staff, Region I, was a relatively simple model which had a rudimentary economic and political system. It was used mainly to introduce participants to a more complex model, Region II.

Region II added a new dimension to simulation in urban affairs by providing an interdisciplinary view of the interrelationships existing among the political and economic structure of a regional area.

Participants of Region II were grouped into eight teams, which functioned as decision-makers, partially on the basis of economic power resulting from the ownership of businesses and partially on the basis of political power available from the votes of the residences they control.

The political sector was restricted in Region II in that it did not allow players enough range of action. Governmental roles were overlaid on a systemic economic structure to build City I.

City I was one of the most complex urban metropolitan models of its type. It was a general model depicting a hypothetical metropolitan area of more then 300,000 population and largely represented the economic and political forces of an urban system.

While City I was a successful educational tool, it was not designed for policy making. In addition it had some other shortcomings. The game did not engender a social conscience among the players other than what they brought to it themselves. The economic sector, although sophisticated, contained a number of misconceptions coming from some land use and terminal structures, the lack of a construction industry and inadequate transportation system. Further, the political sector design was constrained in that it handled only a single political jurisdiction.

The City III Model corrects these shortcomings and considerably enlarges the capacity of urban simulation. The model is programmed so that it can be played on more sophisticated computers, thus increasing its potential use by universities and governments across the country. A still larger model, which will add many more variables such as population characteristics, joint public and private land use and more public institutions, is being designed (Figure 3).

FIGURE 3

DECISIONS

Type	CLUG	Region	City I	City III
Economic				
Purchase & Sell Land	X	X	X	X
Construction or Demolish Business or Residential Operations	X	X	X	X
Set Prices	X	X	X	X
Set Salaries		X	X	X
Borrow and Loan Money		X	X	X
Charge Rent				X
Maintain Buildings	X	X	X	X
Invest in National Stocks			X	X
Boycott Commercial Establishments				X
Governmental				
Set Tax Rates	X	X	X	X
Assess Property				X
Appropriate Funds to Departments			X	X
Request Federal-State Aid				X
Grant Subsidies			X	X
Grant Welfare Payments				X
Build and Operate Schools			X	X
Build and Maintain Highways		X	X	X
Build Utilities	X	X	X	X
Build and Operate Municipal Services		X	X	X
Zone Land	X	X	X	X
Operate Parks			X	X
Provide Bus Service				X
Provide Rapid Rail Service				X
Social				
Vote on Basis of Population		X	X	X
Allocate Time Units				X
Boycott Shopping Locations				X
Boycott Work Locations				X
Boycott Mode of Travel				X

Results

In the City III Model participants make decisions affecting the economic, governmental, and social conditions of a simulated metropolitan area. It is a computer-assisted device in which a system is simulated and the users of the model by becoming the decision-makers of the system and interacting with each other in dynamic situations, change the system.

The users are able to generate a large number of alternative futures in a short period of time as the result of the time collapse feature of these models. Other advantages are that it exposes its users to an interdisciplinary tool that requires a comprehensive approach to issues and problems because "other things" are not held constant; it minimizes the expense of experimenting with public policy decisions; and it illustrates the interrelations that exist in complex systems. The interplay of conflicting and cooperative decisions over time by the users causes the simulated metropolitan area to change in composition and in size. Thus, problems are generated within the play and do not have to be introduced by a referee. Likewise, the evaluation of decision-making is made by the users themselves using the feedback on decisions and not by a judge or referee.

Operating the City III Model

In the City III Model from twenty-one to one-hundred decision-making units with one to five players per unit act as decision-makers in either the economic, social or governmental sectors. The metropolitan size, geographical configuration, and political jurisdiction boundaries are chosen before play from a variety of choices (currently available are 10,000 and 1.5 million population-size communities in various states of balance between the demand for public goods and services and their supply). The simulated metropolitan area is represented on a board comprised of 625 squares, each representing one square mile, many of which are unowned by decision-makers at the beginning of play. Unowned land parcels may be purchased and developed by decision-makers during the course of the game. The eleven types of private land use which economic decision-makers can develop on a parcel of land are: heavy industry, light industry, national service industry, business goods, business services, personal goods, personal services, construction industries, and single family, garden apartment and highrise residences.

Some Basic Differences Among the CLUG, Region, City I, and CITY III Gaming Models

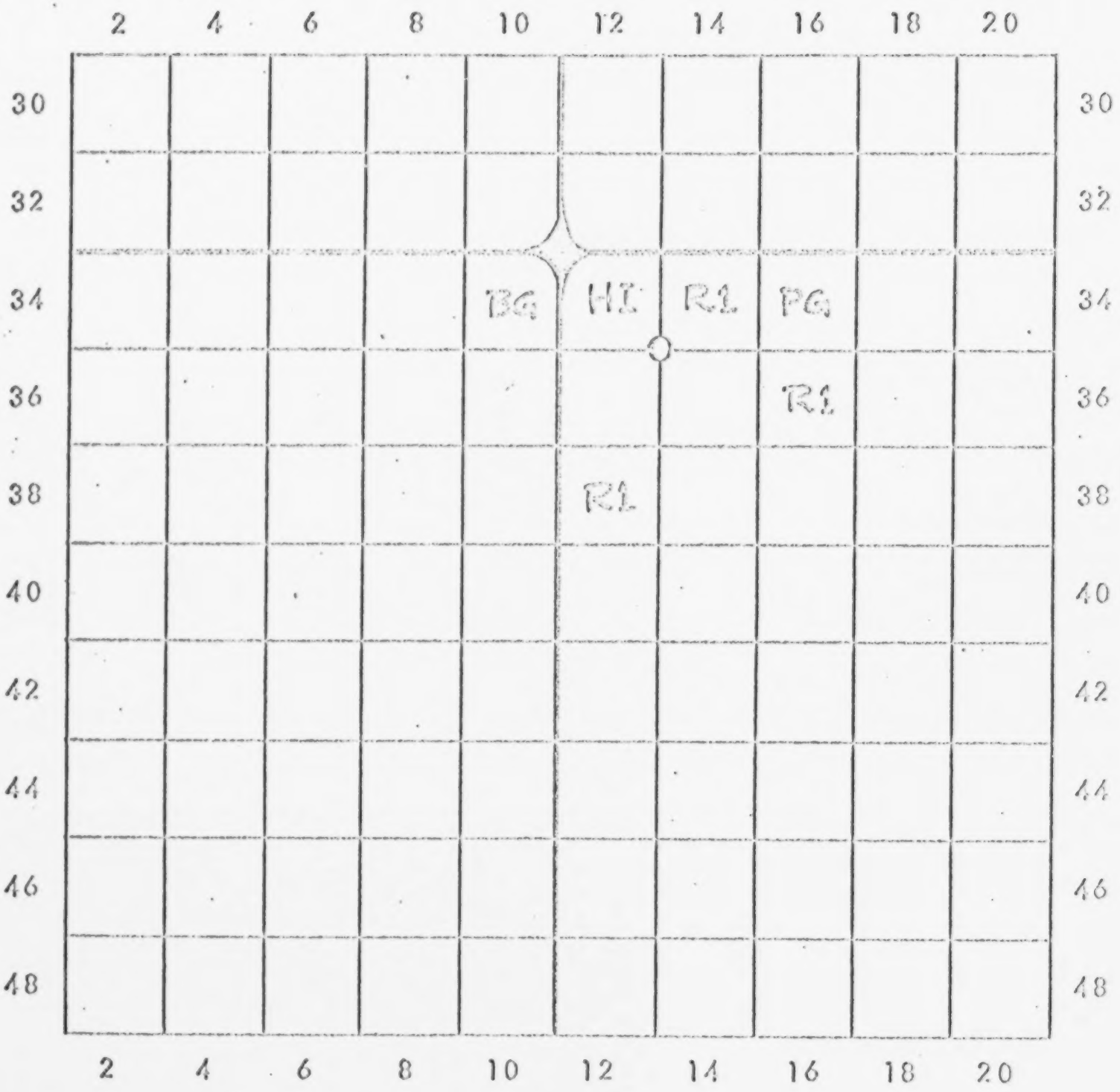
General Characteristics	CLUG	Region	CityI	CityIII
Normal Number of Economic Teams	3	8	9	7-11
Number of Government Functions	0	3	7	10
Number of Social Teams	0	0	0	7-11
Time Simulated with a Round of Play	1yr.	1yr.	1yr.	1yr.
Time Required to Play an Average Round	20min.	45min.	60min.	120min.
Characteristics of a Parcel of Land				
Number of Parcels on the Board	196	900	625	625
Size of Parcels	sq.mi.	sq.mi.	sq.mi.	sq.mi.
Political Jurisdictions	1	3+	1	1-3
Utilities (levels)	1	1	1	9
Zoning Types	0	7	20	15
Owners on a Parcel				
Private	1	1	1	1
Public	0	1	4	7
Parcel Divisions	0	0	8	25
Populations Units				
Types of Units	1	3	3	3
People per Unit	4000	3000	H-3800 M-3400 L-2300	H-500 M-500 L-500
Workers per Unit	1000	10000	H-1000 M-1000 L-1000	H-120 M-160 L-200
Students per Unit	N.A.	N.A.	H-760 M-850 L-690	H-130 M-140 L-100
Land Uses				
Industrial or Basic Industry	HI(1-2)	HI(1-4) FM(5-80	HI(1-3) LI(1-3)	HI(1-3) LI(1-3) NS(1-3)
Commercial or Local Industry	BG(1) PG(1) PS(1)	BG(1) BS(1) PG(1) PS(1)	BG(1-3) BS(1-3) PG(1-3) PS(1-3)	BG(1-3) BS(1-3) PG(1-3) PS(1-3) CI(1-3)
Residential	R(1-4)	RH(1-8) RM(1-8) RL(1-8)	RH(1-5) RM(1-6) RL(1-8)	RA(1-8) RB(1-8) RC(1-8)
Public	none	MS	SC MS HY PK	SC,RR,TM MS,UT HY,PK

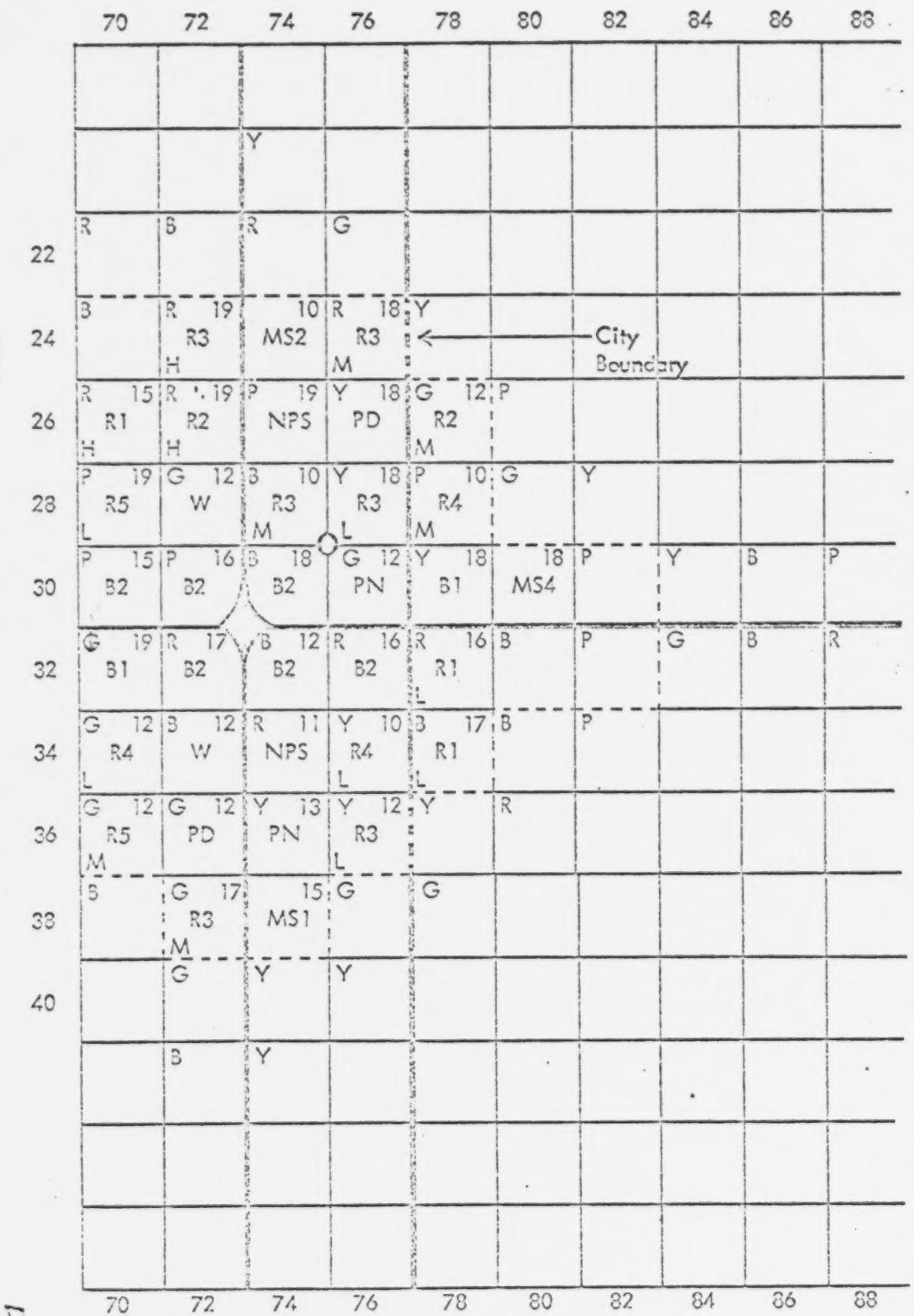
CODE:
HI = Heavy Industry
LI = Light Industry
NS = National Services
CI = Construction Industry
FM = Farms
BG= Business Goods
BS = Business Services
PG = Personal Goods
PS = Personal Services
R = Residences

TRANSPORTATION DIFFERENCES AMONG THE MODELS

Road Types	2	2	3	3
Construction	no	yes	yes	yes
Land Requirement	no	no	yes	yes
Year Construction Period	no	no	no	yes
Operating Characteristics of Roads				
Capacity	no	no	yes	yes
Congestion Charges	no	no	yes	yes
Time Cost	no	no	no	yes
Depreciation	no	no	yes	yes
Others Modes of Transportation				
Bus	no	no	no	yes
Rapid Rail	no	no	no	yes
Assignment Process	no	no	yes	yes
Boycott Possible	no	no	no	yes
Time-Cost Trade Off	no	no	no	yes
Terminals				
Construction	no	yes	yes	yes
Capacity	no	no	yes	yes
Land Requirement	no	no	no	yes

CLUG




70 72 74 76 78 80 82 84 86 88
22
24
26
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30
32
34
36
38
40
City Boundary
R 19 R3 H
10 MS2
R 18 R3 M
R 15 R1 H
R 19 R2 H
P 19 NPS
Y 18 PD
G 12 R2 M
P 19 R5 L
G 12 W
B 10 R3 M
Y 18 R3 L
P 10 R4 M
P 15 B2
P 16 B2
B 18 B2
G 12 PN
Y 18 B1
18 MS4
G 19 B1
R 17 B2
B 12 B2
R 16 B2
R 16 R1 L
G 12 R4 L
B 12 W
R 11 NPS
Y 10 R4 L
B 17 R1 L
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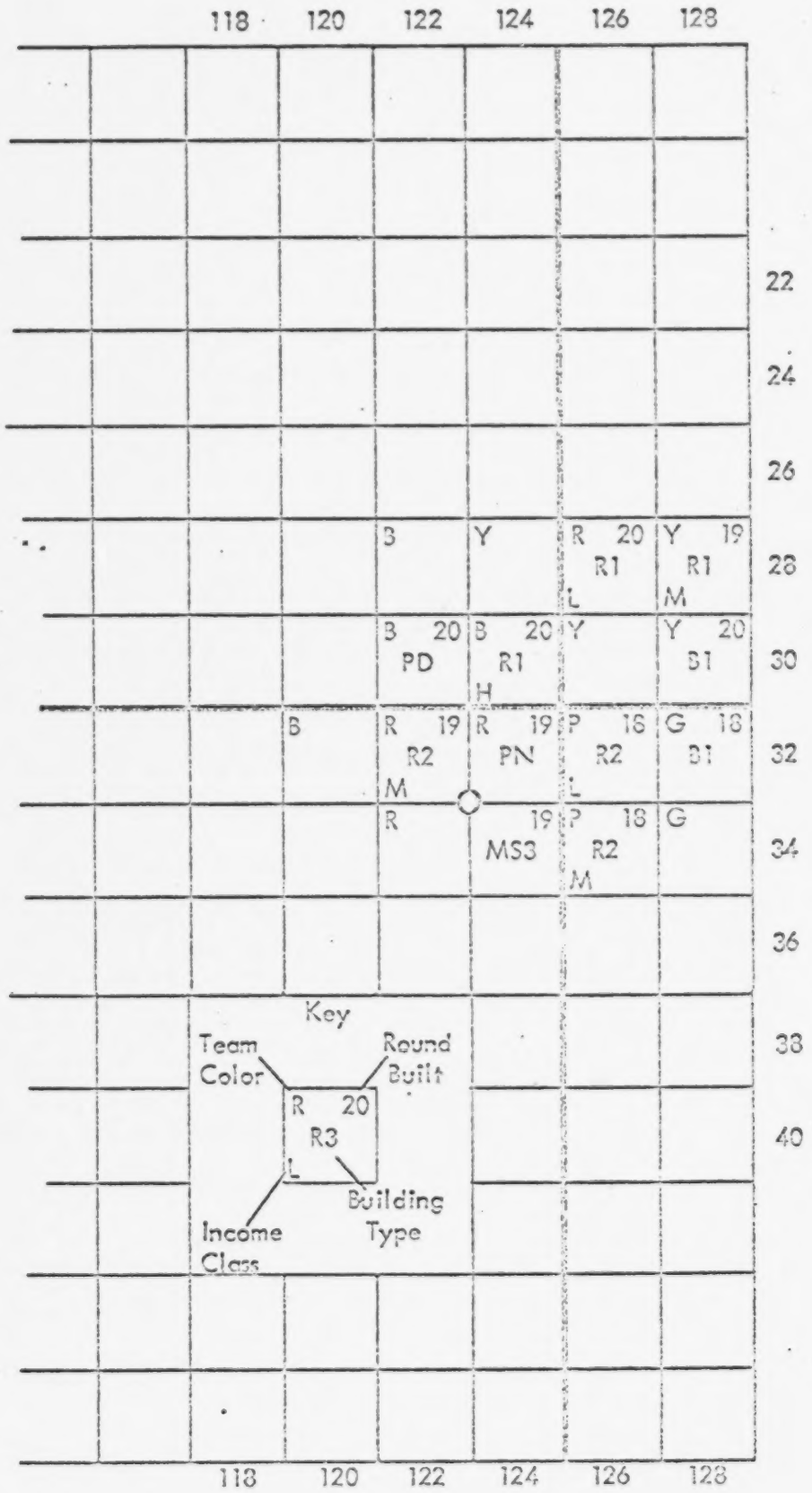
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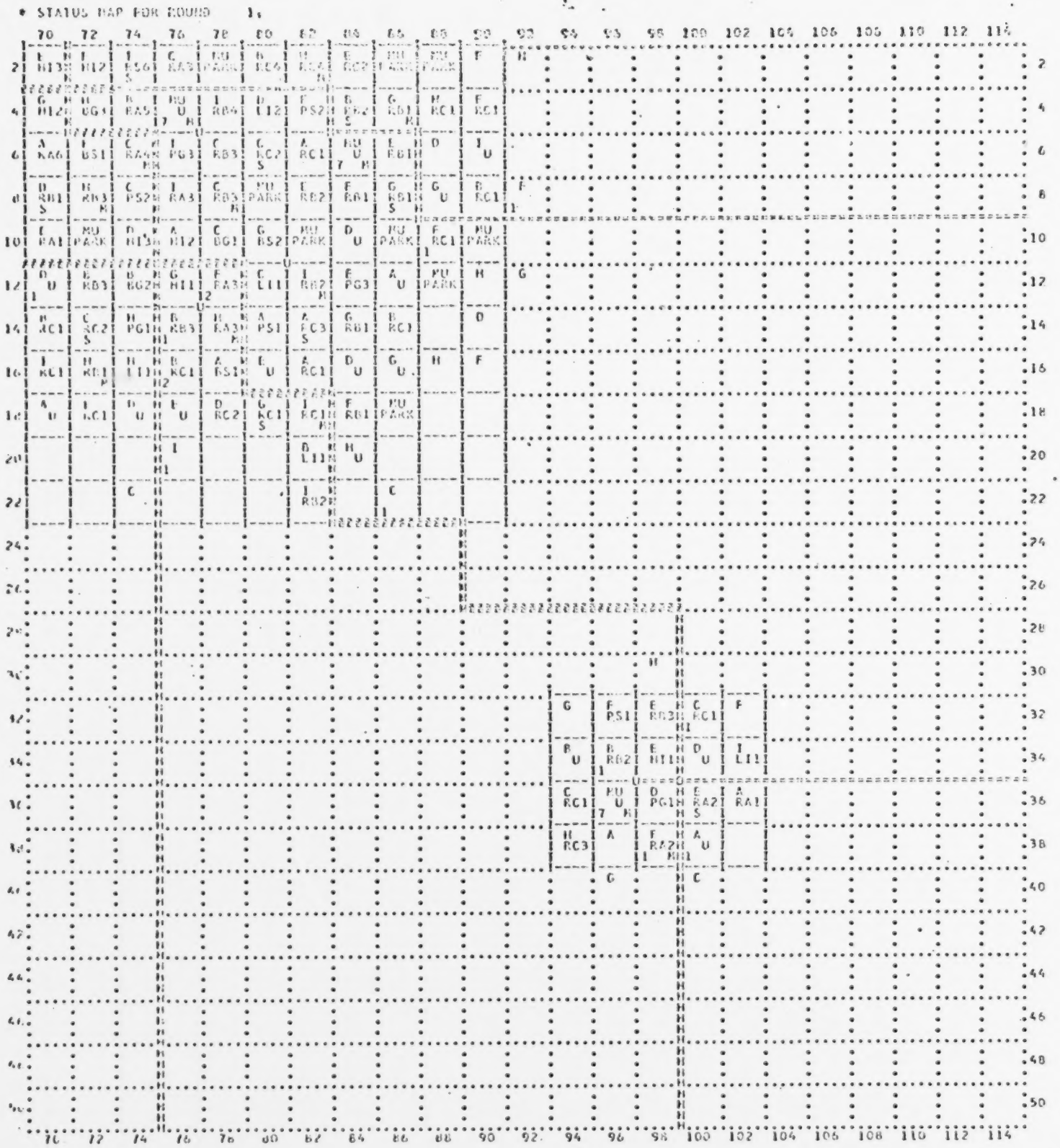
Y
Y 20 B1
B
R 19 R2 M
R 19 PN
P 18 R2 L
G 18 B1
R
19 MS3
P 18 R2 M
G
Key
Team Color
Round Built
R 20
R3
L
Building Type
Income Class

REGION 2

CITY I



PARCEL INFORMATION CODE

TOP LINE: Economic Owner (A thru I)

or Municipal (MU)

MIDDLE LINE: Private Land Use and Level, Park, or Presence of Utility Service (U)

- MI = Heavy Industry
- LI = Light Industry
- BG = Business Goods
- BS = Business Services
- PG = Personal Goods
- PS = Personal Services
- RS = Slum Residences
- RA = Low-Income Residences
- RB = Middle-Income Residences
- RC = High-Income Residences

BOTTOM LINE: Left Side: Units of Park (Maximum is 7)

Middle: School(s)

Right Side: Municipal Service Unit (M)

ROAD INFORMATION

- H or Z - Type 1
- H or = - Type 2
- I or - - Type 3
- ..... - Roadbed

TERMINAL INFORMATION (at intersections of roads)

- O Type I
- X Type II
- ⓞ Type III

UTILITY PLANT (at intersections of roads)

UTILITY PLANT (U)

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PARCELS
TOP LEFT: OWNER
TOP RIGHT: ZONING
MIDDLE: LAND USE AND LEVEL
BOTTOM LEFT: UTILITY LEVEL
BOTTOM RIGHT: % UNDEVL. LAND

CITY III

ROADS
.. .. ROADBED
-- 11 TYPE 1
== HH TYPE 2
TYPE 3
00 00 JURISDICTION BOUNDARY

28

TERMINALS
* TYPE 1
X TYPE 2
* TYPE 3

Master Sheet for the Highway Department

CITY III

General Characteristics

	Highways	Terminals
Land Development		
Typical Construction Costs	$.8m	$14m
Land Requirements*	8%	12%
Depreciation and Maintenance		
Depreciation due to Use	.05Z **	None
Cost per 1% Renovation or Maintenance (Paid to Outside)		
Goods	7,000	
Services	1,000	
Design Capacity (Units)	500	10,000
Federal-State Aid (roads only)		
HY1	$1 for every local $3	
HY2	$2 for every local $1	
HY3	$9 for every local $1	
Population unit consumption of road capacity units comsumed per mile to work	10	
Business and Industry consumption of Terminal capacity units		
HI1		3,000
LI1		1,000
BG1		5,000

* Land requirements for HY2 are 12% and for HY3 are 16% (from both sides of roadbed) and for TM2 are 16% and TM3 are 20% (from all four corners).

** Z = actual use/effective capacity; it is not applicable unless Z >0

Master Sheet for Bus and Rapid Rail

CITY III

General Characteristics

Characteristics	Bus	Rapid Rail
Land Development		
Typical Development Cost		
Underground tracks		$14,000,000/mi.
Surface tracks		4,000,000/mi.
Stations		1,000,000
Land Requirements		4% surface track
Operating Expenses		
Cost of equipment per mile (to outside)	$400,000	$ 800,000
Employment		
Typical cost of labor per mile	40,000	40,000
Units of Labor*	50	50
Depreciation and Maintenance (of equipment only)		
Depreciation (constant rate)	3.5%	3.5%
Typical costs per 1% of Renovation or Maintenance per unit of equipment		
Goods	$100	$100
Service	$200	$200
Passenger Capacity		
Design Capacity (people)	3,000	6,000

[*Bus and Rapid Rail hire only middle income employees.]

Distance for Diagonal Rapid Rail Segments

Horizontal distance between stations

Vertical distance between stations	1	2	3	4	5
1	1.414				
2	2.236	2.828			
3	3.162	3.606	4.243		
4	4.123	4.472	5.000	5.657	
5	5.099	5.385	5.831	6.403	7.071

City III has a political system, which is made operational through use of functional roles, and an economic and social system made operational through systemic play.

Initially, the simulated area can have an almost fully developed central city (with typical accompanying problems) and a partially developed and growing new city, or the land can be undeveloped and unowned, so that participants "build the city" over time. Either way, they learn about the city, its components and metropolitan relationships, the complexities and the human interactions which are involved in this dynamic structure.

The simulated area contains land parcels, each one of which may be developed in a single use, such as industrial commercial, residential or public. Each parcel is owned by one of the decision-makers, by the municipal government or by other owners represented by the computer. Not all land is developed. Property may be bought and sold among teams or bid for from the computer.

A sampling of the types of problems the decision-makers have to solve includes: achieving a proper balance between industry and residences so that residents are employed and factories are operating efficiently; making sure that highway building keeps pace with development (since the computer monitors highway congestion, it extracts higher transportation costs from activities using bottlenecked roads); ensuring that new growth is orderly; ensuring that fair employment is offered, and fair prices charged to representatives of the social sector.

Citizens

Social decision-makers make the decisions for the population units in the metropolitan area. Time allocation decisions (to spend extra time at work, education, politics or recreation), boycotting decisions (not to shop or work at specific locations or not to use particular modes of travel), and voting decisions are made for the three major socio-economic classes of residents in the community.

Government

A Chairman (or quasi-mayor) is elected by the players at the start of the simulated year. The Chairman appoints departmental officials for highways, schools, municipal services, utilities, bus and rapid rail, and planning and zoning.

The election and subsequent actions and reports of officials could provide a forum for establishing new goals and objectives and for the identification of community leadership. This forum would be of particular value in the development of a "sense of community" within the total city and in providing a focus for action programs.

The assignment of government duties to the various players is on a combination elected-appointed basis. This dual function is designed to give the participants a first-hand view of many important public and private interrelationships that are part of community life. Many times this duality leads to conflict of interest, as in the "real" world.

Business

As private entrepreneurs, the players manage their property holdings. Each team owns a mixture of eleven land uses in its portfolio: Heavy and Light Industry, National Services, Construction Industry, Business Goods (which supplies intermediate goods and machinery); Business Services (which supplies "paper" services, such as accounting and computer services); Personal Goods (supermarkets); Personal Services (entertainment and medical services); and three types of Residences. Each business land use may be at one of three levels of development.

Since the players can adjust their wages and prices for competitive reasons, free market interplay continually occurs throughout the year. The printout also itemizes the player's total portfolio in a profit and loss statement and tells the team how much its property is worth, how much cash it has on hand (to be used in the year's planned development), and how much it can borrow. All decisions made by the players become inputs to the computer.

These aspects of the simulation could provide fundamental knowledge of the interrelated aspects of the community's economic base and the identification of critical problem areas. A forecast of economic deficiencies could suggest priorities for community, state, or municipal effort, as well as critical planning phase points.

The Computer

At the start of a year, each player receives a computer printout enumerating his land holdings. The parcels are individually listed by category, showing such information as location, level of development, gross income, taxes, transportation charges, and where appropriate, at what price and from whom it is hiring its workers and/or purchasing its services.

It would be possible here for participants to concentrate their attention on the Model Neighborhood and its requirements.

Decisions are made by the participants. However, both community representatives and local officials can increase their awareness of the computer as a powerful management tool for both the present and the future activities of the community. It is expected that a mutually beneficial long-term municipal-community relationship in the information management area would be one of the fallout benefit of the planning simulation.

A Sample Round

Early in the round participants are reviewing their computer output and trying to order their possible actions into priorities. Economic decision-makers will probably bid on unowned land or acquire desirable land from other participants, attempt to secure loans from local or outside bankers, apply for zoning changes, request utility expansions and pressure for expanded highway access. Simultaneously social decision-makers might be bargaining for higher wages, requesting improvements in local schools and municipal services, and trying to promote the politicians who offer a favorable platform for upcoming elections. The government officials are receiving the requests from economic and social decision-makers to lower taxes, improve the schools, provide better municipal services, expand highways in several different directions, to build additional utility facilities, enlarge the park system, and possibly, to lower bus and rapid rail fares while improving services. Naturally, the budget officials are faced with the difficult task of finding additional revenue to meet the expanding public needs and dividing the local appropriations pie among the many jurisdictions -- all of which have attempted to justify expanded budgets.

Midway, a majority of the decision-makers realize that all their desires will not be fulfilled. .They will have to make trade-offs and bargains. The elected officials begin to worry about staying in office, the departments attempt to make do with sub-optimal appropriation levels, the assessment office tries to minimize the public outcry from changing assessments, the low income representatives endeavor to make their political clout felt, the high income representatives attempt to maintain their status, the businessmen look for shortcut methods of reducing their losses and increasing their activity in profit-making ventures.

Finishing the round the participants seal the bargains they have struck; continue to make decisions for the computer to act on; finish negotiations on construction contracts, new wage levels, new prices, and new rents; spend current and capital appropriations; allocate leisure time to various activities; carry out boycotts; and complete any of the other possible actions.

At the round's end, the participants may campaign for and carry out new elections, hold town meetings, debrief their actions, and/or take a rest break while the computer is preparing a new printout showing how the city responded to their play.

Decisions by Participants

The users of the model make most of the decisions for the local simulated system. External decisions (federal-state policy, migration, and national business conditions are simulated by the computer. The administrator of the model affects the play only by changing the initial starting conditions of the simulated metropolitan area. The following are some of the decisions made by the participants during a run of the model:

Borrow or lend money at various interest rates,
Acquire land,
Sell and trade land,
Build eleven types of private land use developments,
Operate businesses,
Set prices for commercial establishments,
Set wages for businesses,
Operate residences -- set rents and maintenance levels,
Maintain or demolish land uses,
Expand density of land use development,
Raise local taxes from various sources,
Apply for and receive Federal-State Aid,

Balance local budget,
Request and expend funds for department operation,
Build schools and set boundaries,
Hire and assign teachers for day school and adult education,
Hire and assign personnel,
Provide utility service and build utility plants,
Build, upgrade, and maintain raods of various capacity,
Relieve road congestion,
Build and upgrade terminals,
Change zoning -- draw up a Master Plan,
Appeal zoning changes,
Purchase parkland,
Hold referenda for local issues,
Provide subsidies to accomplish public policy objectives,
Invest in national business ventures,
Rehabilitate slum housing,
Test PPBS budgeting,
Experiment with comprehensive planning,
Assess land and developments,
Operate bus company (set routes and fares),
Operate rapid rail system (construct, set routes and fares),
Allocate leisure time of population by class,
Boycott shops, jobs, or modes of transportation,
Affect external and internal population migration,
Vote for political officials.

The City III Model has no formal scoring system. Users are encouraged to measure their performance and the status of their city by their own standards.

Characteristics of Starting CITY III Configurations

City Name	Turiff City & Nairn County Metropolis	Aviemore Cumbernauld Bo'ness	Dunbeath	Lothian	Moray County
GENERAL POPULATION					
Population Size	1,625,000	600,000	275,000	50,000	10,000
Population Scale (people per unit)	500	500	500	50	500
Percent of Population in Each Class					
High	25.7	36.1	37.4	35.0	21.7
Middle	36.5	36.2	35.9	35.0	26.1
Low	37.8	27.7	26.7	30.0	52.2
FIXED MODULES					
Jurisdiction	2	3	1	1	1
Number of Economic Teams	10	10	7	10	10
Number of Social Teams	10	10	7	10	4
VARIABLE MODULES					
Rail	Yes	Yes	No	No	No
Bus	Yes	Yes	Yes	Yes	No
Preempt Land Category	Yes	Yes	No	Yes	No
Developed Parkland	No	Yes	No	Yes	No
Local CI	Yes	Yes	Yes	Yes	No
Assessment Department	Yes	Yes	Yes	Yes	Yes

The Package

The City III package has been assembled so that it is ready for use by educators who understand the model and have access to a computer of the required sepcifications. This final report merely gives some overall background on the City III Model. The final product of the contract must be viewed as the manual and the program tapes.

The manuals describe what the game director, participants, and computer operator must know. The program tape contains the operating computer program and the five starting configurations. These five initial city configurations that were specified by the contract are described in the following table in terms of their major characteristics.

Note that the five starting positions offer a great deal of flexibility in terms of number of teams, population size, population mix by income class, and the variable modules. Quite often the overall objectives of the game director or circumstances will either dictate the use of one city or another or preclude the use of one city or another. For example, if it is desired to have multiple jurisdictions then one of the first two starting cities should be chosen. If the class size is very small (less than 15) it would be very difficult to use other than the third and fifth choices.

Conclusions

As a result of more than three years of experience in the development and operation of educational decision-making models, and particularly as a result of the work performed on the City III project, it is the feeling of the staff at Envirometrics that gaming models of the City III type will be extremely valuable and flexible educational devices. Eventually in many circumstances, the student and the teacher can use the City III Model for a wide range of experimental and research purposes. Whereas students may become caught up in the battle to balance a budget, create a new town, develop a utopian city (in their own terms), or a number of other endeavors, the teacher may use the vary same model to test on students the impact of playing a complex versus a simple version of the game, of having limited information versus full information, of having adiverse decision responsibilities versus specialized responsibilities, or of playing the model under a number of other sets of circumstances.

The accompanying manuals describe City III in more specific detail, and are outlined below:

1. Players' Manual -- describes to the first-time player the decision-making sectors of the model, the computer output, the basic model parameters, and methods for the input of decisions to the computer.

2. Game Director's Manual -- details the flexibility of the model, the choice of starting positions and modules, the formation of teams, the running of a round, and the use of complementary material. In addition, it outlines the procedure for operating the model on the Univac 1108 system.

3. Operator's Manual -- describes the various programs and outlines the steps necessary for executing the model on a Univac 1108 system.